NONVERBAL INTERACTION IN SMALL GROUPS:
A METHODOLOGICAL STRATEGY FOR STUDYING PROCESS

A Thesis
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by
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ACKNOWLEDGEMENT

The idea for this study came as a result of discussions with Leonard C. Hawes and Robert W. Wagner. Their continuing personal and professional support have been invaluable both for this thesis and for my intellectual growth. To them, infinite thanks.
ABSTRACT

Nonverbal interaction process in four triadic discussion groups was examined for this study. Through time lapse photography, discrete visual time samples in the form of film frames were analyzed. Each frame defined a state of the interaction process.

Configurations of group behavior for each of three levels of the nonverbal communication subsystem (head, body, and arm movements) were coded from each frame. Through the Stochastic theory of Markov chains, sequences of configurations, then, operationalized group process.

The research questions directing this study concerned the characteristic nonverbal behaviors displayed during group interaction, the characteristic sequences of behavior, and the stability of these behaviors across similarly structured groups.

Results indicated that sequences of head movement are extremely varied; body and arm movement sequences are more predictable. The most frequent sequence of behavior is for each level-configuration to remain constant from t to t+1. Behavior sequences are not stable across groups, however.

This application of the time lapse photography-Markov analysis design shows promise for further investigations of nonverbal process.

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RATIONALE

INTERACTION

"Studies of interaction, whoever the subjects and whatever the situations, presume communication whereby the participants in an interchange influence one another."¹ A student raises his/her hand in class and anticipates being called on by the teacher. A mother stretches her arms toward a toddler and the child moves toward the parent. During a casual chat with a friend, an individual speaks, waits until the friend replies, and then probably speaks again. One act (the smallest unit of communication or behavior) influences a subsequent act. By our actions we stimulate and, to some degree, mold another's actions. The result is interaction.

When we communicate with another person, we cue our own behavior displays and base our own as if assumptions on what we see and hear the other person doing. When we observe the communication of others, we must ground our study in behaviors which other people can observe too.²


The as if assumption referred to above is concerned with the notion that in a communication situation we continuously behave (verbally and nonverbally) "as if" our actions "mean" the same to others as the "mean" to us. But to have meaning, the behaviors must be patterned and dependable.

"Logically speaking, were it not that interactions were patterned, behavior would be unpredictable and unreliable, and it would be impossible to sustain, mediate, and form human relationships, complete coordinated tasks, and transmit a common culture."3

Interaction includes a variety of behaviors. Although one person may exhibit patterned behavior, at least two people must engage in these patterns for interaction to occur. A's antecedent act is said to "interlock" with B's subsequent act forming a pattern of interdependent behavior.

These patterns define the relationship between the interacting persons. How, where, and when they interact gives clues to the nature of their affiliation. "Interational systems, then, shall be two or more communicants in the process of, or at the level of, defining . . . their relationship."4


In sum, people mutually influence each other while communicating. This interaction functions not only to exchange information but also to define relationships.

THE GROUP

Inasmuch as the definition of interaction stipulates the participation of two or more people, it is necessary to focus on the group as the basic unit of interaction analysis.

A person spends most of his waking hours interacting in one group or another. There are family groups, groups of friends, business partners, club groups, fraternities, sororities, committees, and athletic teams. Mills estimates that the average person belongs to five or six groups simultaneously and that there are approximately four or five billion established small groups (usually containing less than twenty members) in existence. For the study of human behavior, a thorough investigation of the group process is in order.

Individuals join groups for many reasons. Groups offer satisfaction for certain individual needs, and groups work to achieve mutual goals or rewards. To accomplish these ends, the individuals interact. A simple definition of group,

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then, is "two or more persons who are interacting in such a manner that each person influences and is influenced by each other person."  

In addition to the impact of the group's widespread prevalence in human life, there is another reason for its study. When participating in groups, individuals often behave differently than when alone.  

"Personality measures generally do a poor job of predicting how people will behave in groups, and there are many reasons for saying that the actions of individuals are shaped by the interdependencies that prevail in groups." Therefore, the group may be viewed as a holistic entity.

If a group is thought of as a system, each person's influence is dependent upon the needs of the group at any given time. Each participant adjusts to the others, and this mutual interdependence is vital for the group's maintenance.

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GENERAL SYSTEMS MODEL

For the purpose of this study a group is conceived as a single entity (system) composed of group members (components) who interact using verbal and nonverbal behavior (elements) in patterns (repeated behavior over time). Since the emphasis is on group structure and process, the most appropriate model for generating the necessary holistic data is one designed in the general systems theory tradition. "(T)he systems method advocate(s) a holistic treatment that studies the structure, function, and behavior of an entire organism—whether that organism is a single cell or a sprawling society." 10

General systems theory is a set of related definitions and assumptions about all levels of systems from atomic particles through galaxies. A system is a set of interacting components within a boundary. 11 To explicate this definition it is necessary to farther define each of the terms.

Def. 1: A set is a group of units with common properties.

Def. 2: A component of a system is a unit that, in combination with other system units (subsystems), functions to combine, separate, compare or contrast the inputs to produce the system's outputs.


Def. 3: A boundary of a system separates that system from another and further filters the kind and the rate of flow of inputs to and outputs from the system.

Def. 4: An input is any energy absorbed by the system or the information introduced into it.

Def. 5: An output is any energy, information, or product that the components discharge from the system.¹²

Two further definitions are necessary for understanding the terms used to describe group in this paper.

Def. 6: An element is a means by which components process inputs.

Def. 7: A pattern is a non-random arrangement of elements recurring over time.

Systems contain subsystems which may themselves be examined as systems. Since all communicative behavior may be treated as elements by which components combine, separate, compare and contrast inputs, the nonverbal level of group communication may be treated as elements defining a subsystem of the group's total communicative interaction.

The elements are arranged in one pattern at time t and in another pattern at time t+1.¹³ To better understand group process and structure, the patterns of these elements must be studied.

¹³ Ibid.
METHODOLOGICAL STRATEGIES

Systems are temporally as well as spatially based. Thus the notion of time is important. Yet research on process (the sequential occurrence of behavioral units over time) has had only a skeletal beginning. "All process research to date . . . has been exploratory . . . . The serious methodological problems encountered sobered investigative enthusiasms (and) frustrated research hopes."14

One of the research fields especially concerned with process has been psychotherapy. Studies of the effects of psychotherapeutic encounters are greatly complemented by studies focusing on the nature of the encounters (i.e. what behaviors are displayed by patient and therapist during their encounters). Unfortunately, such process studies are limited by inadequate research methods.

Traditionally, three basic designs have been applied to process research.

1. using pre and post event tests;
2. counting repetitions of categories of behavior during the event, and

3. calculating the transition frequencies between categories of behavior during an event.\textsuperscript{15}

The first strategy compares an arbitrary initial state and final state to generate a measure of difference. Any variance is attributed to change and is said to operationalize process. Thus, "process is treated as one large unit ... rather than an unfolding series of small units moving toward some end."\textsuperscript{16}

This rather simplistic view is superceded by the second design. By making a frequency analysis of some categorized behaviors during a psychotherapy session, some valuable information may be gained regarding the behaviors most often displayed. The one-chunk idea is replaced by a multiple unit notion of process. But there are limitations here, too.

The second strategy ignores the sequential occurrences of behaviors, i.e., the ordering of behaviors. Similar frequencies of behaviors hypothetically may be manifested in completely different sequences, and similar orders of behaviors may be displayed in comparable events, but with different frequencies.


\textsuperscript{16}\textit{Ibid.}, 422.
In an attempt to accommodate order in the operationalization of process, the third design was conceived. Frequencies are again obtained, but the frequencies are of transitions (e.g., how many times does category B follow category A). Process is operationalized as one-step behavior transitions. The larger process, of which these discrete behavior transitions are a part, is ignored.

The actual psychotherapeutic encounter may be viewed clinically and experimentally as essentially a very long sequence of behaviors emitted by both patient and therapist. Within this stream of behavior may be seen a dynamic configuration of many interrelated processes.\footnote{Richard K. Hertel, "Application of Stochastic Process Analyses to the Study of Psychotherapeutic Processes," \textit{Psychological Bulletin}, LXXVII (1972), 423.}

One difficulty with the multi-variable concept of process is a lack of appropriate statistical measures for its analysis. The limitations of the past research designs may be due in part to this fact. Relatively recently, however, a mathematical model for studying process has been applied to the third design focusing on the transitions between categories. By transforming the transition frequencies into probabilities, a Markov chain is generated.
The simplest Markov chain is that in which there are a finite number of states or categories and a finite number of equidistant time points at which observations are made. Such a chain is described by the initial state and the set of transition probabilities; namely, the conditional probability of going into each state, given the immediately preceding states.\textsuperscript{18}

Through the Markov chain, series of transitions can be described, complex behavioral patterns (transitions repeated over time) and the most probably sequence becomes operationally definable. And, with a chi square goodness-of-fit test, an assessment of stability or change may be derived.

Some studies which have applied the Markov model are discussed in the next section.

RELATED STUDIES

TRANSITION ANALYSIS

Raush employed a Markov model to study affectional behavior among children, comparing sequences of interaction between hyperaggressive and normal boys.¹⁹

Observations of who was doing or saying what to whom were dictated into a tape recorder in the order of occurrence. Later the tapes were transcribed and then coded onto lined data sheets. This multi-step collection method is awkward but Raush indicates that by calculating transition probabilities between the categories he finds among peers, affectional relations are strongly contingent—that is, what A does affects B's responses; that the same kind of act will have different consequences depending on the situation; and that the same kind of act is apt to be interpreted and reacted to somewhat differently by different groups.²⁰

He also claims that by studying sequences or chains of action through these methods, a prediction of peer behavior corresponding to an R of more than .60 may be made if the situation, nature of the group, and the actions of an interacting person are known.

²⁰Ibid., 497.
Hawes and Foley similarly applied a Markov model to their study of interview communication.21 Interviews were audio-recorded. Communication behavior was sampled and coded at five second intervals. These category codes were then analyzed for transition probabilities.

One research question that interests them concerns the stability of sequential patterns of verbal behaviors over time. They find support for their hypothesis of stability. Although structural differences exist in behavior sequences across communication systems, these differences remain stable over time. Thus sequential behavior patterning is set early in the interactions and remain stable throughout the interaction process.

Levis also found stability in group process.22 Instead of interviews, he examined discussion groups. Speaker switching and initiation of participation were recorded then later transcribed and coded. Through one-step transition analysis, sequences of participation initiation and speaker switching became evident.


In agreement with Hawes and Foley's results, Lewis finds that, for most groups, stationary parameters (i.e. constant or stable probabilities determining the outcome of process) within a session are not rejected. Often the assumption of stationary parameters from group session to group session is rejected. Therefore, a group interaction whether it be a dyadic interview or a small group discussion, remains stable over time. Stability is not found across groups.

These studies indicate the heuristic value of a Markov model for examining process. More research in this vein is necessary, though, to generalize about process with any reliability. The present study was conceived for this purpose.

On examining process and group research, it is apparent that few studies have focused on nontherapeutic discussion groups. Furthermore, as the behaviors coded were generally verbal, there is very little known about nonverbal interaction in groups.

THE NONVERBAL SUBSYSTEM

This study focuses on the nonverbal elements of group interaction. As used here, nonverbal communication includes any bodily movement an organism may display during a communication situation.
By concentrating on the sequential patterns of nonverbal behaviors, a partial syntax of nonverbal behavior in group interaction might ultimately be constructed. But before arriving at that end, much descriptive material must be gathered from all types of groups in all types of circumstances since the existence of different interactional rules and norms for different contexts is assumed (e.g. a bible group in a church behaves differently than a group of drinking buddies in a bar).

Though many more investigations are essential for an adequate understanding of the patterns of nonverbal elements in communication, a solid start has been made. And even though process is not specifically discussed, a few studies describe sequential and/or repetitious behaviors during interaction. It is interesting that they are moving toward a transition probability idea of process from a base of observing repetitions of sequential behaviors.

Kendon investigates eye contact direction and duration during a discussion.23 He finds changes in a listener's behavior before beginning to speak. He also isolates an individually characteristic head pose which is assumed by each speaker when bringing a long utterance to a close.

Through the combined use of time lapse photography (taken during five of the last ten minutes of each session) and direct observation, Kendon shows a common pattern of changes in direction of gaze. Each speaker tends to look away from the partner as she/he ends a long utterance (and sometimes slightly in advance of it). As the utterance is completed, the speaker looks steadily at the listener.

Kendon's description of some one-step transitions is simplistic but suggests a possibility of interesting characteristic sequences emerging if the Markov model is applied.

Schefflen, too, defines repetitive sequential nonverbal behaviors. By using the orthograph (lexical transcript) and postural-kinesic topograph (plotting gross postural configurations on a time graph), he examines the psychiatric interview very closely.

He finds a rhythmic flow of patterned behavior. This he compares to a musical composition. Within the interaction, repetitions of behavior seem to mark parts of the interview, comparable to the elaboration of themes and subthemes passing through structured and measured musical intervals and movements. Thus, by observing a behavior, it

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is possible to infer what had gone on before and what likely will follow.

As these studies indicate, a relatively unexplored field contains potential for the application of a transition probability model to operationalize process. Through an adequate sampling method, it should be possible to seek answers to the following questions:

1. What are the characteristic nonverbal configurations displayed in small group discussions?

2. What are the characteristic sequences of behavioral configurations in small group discussions?

3. To what extent are these sequential configurations stable across similarly structured groups?
METHODOLOGY

To answer these questions through the use of the Markov model, a collection strategy is needed to supply the appropriate data.

In the past, interaction studies have employed a tape recorder for aural observations and/or several experimenters who manually code visual observations. Other researchers have preserved the interaction on either videotape or motion picture film.

Motion picture films have recently gained considerable stature as a means to collect records. The interest in filming is understandable because motion picture records have several advantages. Michaelis noted that films have permanency, there is no limit to the size and complexity of the event that can be recorded, their range of time and velocity is greater than the human eye—if actions occur too slowly the film-maker can use time lapse photos; if events occur too rapidly the film-maker can resort to slow motion—films permit time sampling, film emulsions are more sensitive than the eye, and cameras can be concealed.25

Both film and videotape are superior to "live" coding. Complex events may be recorded for later analysis. Events

of long duration may be recorded without loss of coding reliability due to observer fatigue. The stimulus and behavioral response may be viewed again and again. And the film may become a permanent resource in a library of behavior, available to other researchers who want to replicate, study, or build onto that empirical record.

The clarity and analytic flexibility of motion picture film are important to this study. A special technique, previously used to record such things as traffic patterns and blooming flowers, provides a means of sampling an interaction process. The technique is

memo-motion or time lapse photography, in which the camera speeds such as 1 fps (frame per second) instead of the usual 24 fps produces films which are invaluable to detect patterns of movement... The principal advantages of memo-motion technique are that they reduce the costs of film (gross details are preserved at about 6 percent of the normal cost of film), they permit time sampling, and they facilitate analysis... Projection equipment especially adapted to memo-motion film permits the observer to study one frame at a time for as long as he wishes... Because of the set rate at which the film is exposed, accurate time records of an event are available without elaborate timing equipment being placed in view of the lens.26

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To record all behaviors of even a short interaction process is an overwhelming task. Time sampling represents a valid shortcut. Heretofore, time samples were elicited by observing and recording at intervals (e.g. Wright and Proctor alternately watched and recorded at 15 second intervals). But time lapse photography produces a more systematic sampling of time. The product is a series of still images, evenly spaced throughout the interaction process. Each image represents a state of the interaction process. Therefore, the state of the interaction system is defined by the relationship among elements at a given time.

Data can be coded directly from the resulting still images and since the interaction is preserved on film, no observers need be present during the recording of the group discussion.

SAMPLE

The Ss, six males and six females were taken from a large basic communication course at The Ohio State University. They were experimentally naive and previously unacquainted with one another.

The twelve Ss were separated into four triads, each sexually homogeneous. To eliminate coalition formation due to sex attractiveness, two all-male and two all-female groups were studied.

The triad was chosen for observation. It is small enough that each participant has ample opportunity to communicate and it is easier to observe than a larger group. Furthermore, a triad . . . is less vulnerable than a dyad. If one person leaves, the social unit still remains. But if one person leaves a dyad, the social unit dissolves. The transition from three to four creates the possibility of two equal dyads or alliances, and this may perpetuate both the social unit and the problems of control.28

Even-numbered groups, then, lack stability since power stalemates lead to more disagreement than is generally found among uneven coalitions such as the triad.29

FACILITY

Two experimenters, one cameraman, and one soundman participated in this study. Filming was done in a conference room at the Behavioral Science Laboratory of The Ohio State University (see figure 1 for the arrangement of the room).


29Weick, "Systematic Observational Methods."
fig. 1.--layout of experiment area
Two motion picture cameras were used, one sound-on-film and one time lapse. The sound camera was an Auricon 1200 with a 16mm Switar lens. The microphone was a 630 Electro-voice. A key light, a 650 nook light was positioned next to the sound camera and about six feet from the experiment area. The soundman and cameraman were stationed at the back of the room, partially hidden by a semi-closed partition. They were instructed to concentrate on the equipment so as not to distract the Ss.30

Two more fill lights, 1000 watt Softlites, were placed against the side walls to soften shadows in the experiment area. Suspended from the ceiling above the table where the interaction occurred was an Arriflex "s" camera with a 10mm Schneider lens and fitted with an Arrie time-lapse motor set to shoot one 1/4 second exposure every two seconds.

The Ss were seated on three heavy arm chairs which surrounded a round table approximately three feet in diameter and four feet high. The size and shape of the table were important. Past studies indicate that interaction occurs

30Robert T. Bales' report ("A Set of Categories for the Analysis of Small Group Interaction," American Sociological Review, XV (1950) included a discussion of observer influence in research. He indicated little significant effect. Thus, this researcher was worried less about the effects of the technicians' presence than about the effect of the bright lights and somewhat noisy cameras on the interaction of the groups.
more frequently between Ss who are seated opposite each other than those who are adjacent. With the compact seating arrangement and circular placement, Ss were equidistant from one another.

To further promote equal participation among Ss, the groups were made small and sexually homogeneous and the task selected for the groups was open-ended and ambiguous so there would be no "experts." This final strategy was included since "communication within a small group is most

31 Several studies influenced the seating arrangement strategy used in this investigation. Steiner suggests that interaction occurs more frequently between subjects who are opposite each other in a circle than those who are adjacent. Similar findings were established by Hare and Bales while studying a five-member discussion group seated at a rectangular table. Howells and Becker's study of five-member groups seated at rectangular tables indicated that subjects on the two-person side of the table, in order to compensate for their lack of number, were found to do more talking. Ward also studied five-member groups. His groups, however, were seated in a circle. Three extra chairs were placed into the circle so that two of the subjects were completely isolated by empty places. Consistent with previous findings, the two occupants of those separated chairs talked more than did any of the three adjacent subjects. To neutralize this effect, the present study used a small round table with only three seats. See Bernard Steiner's "The Spatial Factor in Face to Face Discussion Groups," Journal of Abnormal and Social Psychology, XLV (1950); A. Paul Hare and Robert F. Bales' "Seating Position and Small Group Interaction," Sociometry, XXVI (1963); L. T. Howells and Selwyn W. Becker's "Seating Arrangement and Leadership Emergence," Journal of Abnormal and Social Psychology, LXIV (1962), and Charles D. Ward's "Seating Arrangement and Leadership Emergence in Small Discussion Groups," Journal of Social Psychology, LXXIV (1968).
nearly equal among the members when no one of them possesses special competence and when there are no clear answers to the question at hand."32

PROCEDURES
The Ss of each triad chose their own seats (marked X, Y, and Z). Each S received a copy of the following human relations problem:

I think my roommate at college is emotionally disturbed. She is always very nervous and depressed. She seldom speaks to anyone. At night sometimes she screams in her sleep. Everything she owns is under lock and key. Last week, by accident, I spilled hot coffee over one of her books and she accused me of doing it intentionally. I advised her to seek professional help for her problems, but she told me to mind my own business. Am I right in thinking she needs help? Under what conditions, if any, should I seek help for her without her knowledge?33

After Ss were given time to finish reading the paragraph, the experimenter read the following instructions so that all instructions to all groups would be standardized:


Your task is to come up with the best possible solution for this problem that you can. The problem should be discussed thoroughly until a group solution is reached. That solution is the advice which your group would give to the troubled person in the problem.

You have fifteen minutes for your discussion. Are there any questions before you begin?

The experimenter then left the room, returning after fifteen minutes to signal the end of the discussion. At that time, Ss were debriefed. One of the questions the experimenter asked was whether Ss ever "forgot" the cameras' presence during their discussion. Seven replied that they forgot the cameras sometime during the first half of their conversations, two more said "toward the end" and three said "never."

The time lapse camera recorded continuously during the two hour period used for the study. The sound-on-film camera only recorded the fifteen minute interactions to serve as an independent check on the effectiveness of the 1-frame-per-two-seconds time sampling, and to create a verbal and nonverbal interaction resource material for future study.

Unfortunately, after the film's processing, the researcher found that the overhead camera had not included all of the interaction field in its frame. There was not enough information for accurate coding of data since only two of the three group members were always in view. This temporary
setback was easily surmounted though. Both the time lapse and sound films were loaded on a Steenbeck editing bench. The bench had two viewing screens. By setting the counter for 48 frames, the 24 fps film was sampled in the same manner as the time lapse had sampled real time. Therefore, overhead and side views of the same time sample were examined simultaneously.

The coding consisted of "x"ing out the appropriate boxes on the coding sheets (see appendix). In this manner, fourteen hundred frames were analyzed for each group.

**ANALYSIS**

"(A) category is a statement describing a class of phenomena into which observed behavior may be coded; a category system consists of two or more categories."\(^{34}\) Coding from categories can be extremely complex. For this study, however, coding was relatively simple and required little inference. No coder reliability check was made inasmuch as coding was so straightforward. When any doubts arose regarding one of the categories, the researcher conferred with a photographer who was aiding her and they reached a consensus.

Three levels of nonverbal communication were selected for study: head movements, body movement and arm movement. These nonverbal levels were divided into six categories.

Head direction
1. Head to someone. Was S looking toward another S?
2. Head away. Was S looking anywhere other than toward another S?

Body position
3. Body forward. Was S leaning forward?
4. Body back. Was S leaning backwards? A piece of clear celluloid with a simplified grid was placed over each viewing screen for a common referent for judging the arbitrary line between forward and back.

Arm extension
5. Arm or arms extended. The arms of the chairs provided a visual guideline for discerning this. Any movement of S's arms past the sides of the chair or above table height was considered an extension. Moreover, any blurred image of the hands or arms was considered an extension since they were moving at the time of the sampling.
6. Arms together. Were S's arms crossed, hands clasped or arms at sides? Hands resting on the table were coded as arms together.

Each frame of the time lapse film constitutes a time sample defining the state of the interaction system for that point of the interaction process.

The three levels of the nonverbal subsystem were categorized binarily.
1. Head to someone (1); Head away (0)
2. Body forward (1); Body back (0)
3. Arm or arms extended (1); Arms together (0)

Each level of the nonverbal subsystem was coded separately for each group. For example, the head direction of the entire group was coded together. If, in one time frame, X was looking at Y (1), Y was looking at X (1), and Z was looking at his/her hands (0), the interaction of the head level was coded as a "110" configuration. Thus the interactive aspect of the head level for the group as a whole was emphasized, i.e. the "110" configuration defined the state of the interaction head level at that time. Before examining the next film frame, the group body position was viewed. If X was leaning forward and Y and Z were leaning back, the configuration was coded "011." The arm extension was coded in the same manner. Then the researcher similarly coded every other frame of the time lapse film.

To summarize, each frame of the film was treated as a state of the system. Each state was defined on three levels, each level capable of taking on one of eight configurations (see table 1). The possible levels-configurations were consecutively numbered for subsequent computer analysis.

During analysis, each level was separately examined within groups and across groups. The frequencies with which
### Table 1

**Configuration Notation System**

<table>
<thead>
<tr>
<th>Configuration notations for nonverbal levels of interaction</th>
<th>111</th>
<th>011</th>
<th>001</th>
<th>000</th>
<th>100</th>
<th>110</th>
<th>101</th>
<th>010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head direction</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Body position</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Arm extension</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
</tr>
</tbody>
</table>

The remaining tables indicate the binary configuration notations by the level numerical key. For example, a state may exhibit configuration 2(011) for head direction, 9(111) for body position, and 21(100) for arm extension.
the system moved from one configuration to another were determined. From that information an 8 x 8 level-configuration transition probability matrix was constructed (see table 2). The rows are time t level-configurations and the columns—t+1 level-configurations yielding sixty-four one-step (i.e. first order) transition cells.

The frequencies were then converted to proportional data. By using a transition analysis technique, these data provided transition probabilities for each level-configuration at t being followed by each of the eight configurations for that level at t+1. By preparing these transition probability matrices and a composite matrix representing all groups, the stability of the interaction process across groups is assessed.

The transition probabilities are assumed to possess Markovian properties. To review:

A first-order Markov chain is a stochastic process in which the future state of the process, given its present state, is independent of its past history, i.e. its state at t+1, given its state at time t, is independent of its state at times t-1, t-2, . . .

35 Hawes and Foley, 209.
<table>
<thead>
<tr>
<th>head level configurations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.33</td>
<td>.21</td>
<td>.21</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>2</td>
<td>.15</td>
<td>.33</td>
<td>.38</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>3</td>
<td>.00</td>
<td>.14</td>
<td>.46</td>
<td>.15</td>
<td>.00</td>
<td>.00</td>
<td>.15</td>
<td>.00</td>
</tr>
<tr>
<td>4</td>
<td>.00</td>
<td>.00</td>
<td>.27</td>
<td>.46</td>
<td>.00</td>
<td>.02</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>5</td>
<td>.17</td>
<td>.00</td>
<td>.33</td>
<td>.33</td>
<td>.00</td>
<td>.00</td>
<td>.17</td>
<td>.00</td>
</tr>
<tr>
<td>6</td>
<td>.00</td>
<td>.25</td>
<td>.00</td>
<td>.50</td>
<td>.00</td>
<td>.00</td>
<td>.25</td>
<td>.00</td>
</tr>
<tr>
<td>7</td>
<td>.00</td>
<td>.00</td>
<td>.30</td>
<td>.21</td>
<td>.00</td>
<td>.00</td>
<td>.25</td>
<td>.00</td>
</tr>
<tr>
<td>8</td>
<td>.21</td>
<td>.00</td>
<td>.00</td>
<td>.36</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.21</td>
</tr>
</tbody>
</table>

To eliminate any probabilities which may be due to chance alone, only those probabilities larger than .125 were included.
So the probability of the nonverbal subsystem entering a certain state is assumed to be dependent only on the current state of that system.

Since the transition probability model focuses on the transitions between consecutive states, a diagram of those probable transitions serves to map the process of the interaction. 36

Thus, the observed transition frequencies and transition probabilities (i.e. the frequency and probability of the system entering each of the eight level-configurations) were compiled. 37 Entropy, "the certainty with which the subsequent state can be predicted if it is known that the system is in any given state," was computed as was the relative entropy of the eight level-configurations of the nonverbal process. 38 Finally, the equilibrium probabilities, the probabilities of each state when maintaining the observed transition probabilities for an indefinite time, were calculated from the matrix by the simultaneous solution of a system of linear equations as described in Ashby. 39

36 Hawes and Foley, 289.
37 The computer program used for analysis was developed by Joseph M. Foley of the Department of Communication at The Ohio State University.
38 Relative entropy is the ratio of each state entropy to the maximum entropy. Maximum entropy is the value of each state given that each state has an equal probability of being occupied.
To provide more precise answers to the research questions, Anderson and Goodman's likelihood statistic was applied. This tests the null hypothesis that the transition probability matrices for each group interaction are not significantly different from the composite matrix of all group interactions.

Through the combined use of time lapse photography for data collection and the transition probability technique for analysis of the data, certain behavioral patterns (i.e. transitions from one configuration at t to another at t+1) became evident.

---

40 Anderson and Goodman, "Statistical Inference about Markov Chains."
RESULTS

Included in this chapter are a series of tables and figures which present a visual map of the most frequent configurations displayed in each nonverbal level for each group. However, some explanation of terms is necessary for data interpretation. In this study, the range for entropy is from 0.0 to 3.0 bits. The lowest entropy indicated "absolute certainty of prediction—the antecedent state is always followed by the same subsequent state."\(^{41}\) High entropy shows "maximum uncertainty of prediction—the antecedent state is equally likely to be followed by any subsequent state."\(^{42}\) Thus, for low entropy, the probability matrix identifies the states (configurations of nonverbal levels) most likely to follow the occupied state. But with high entropy, the matrix indicates that any of several configurations are likely to follow.

Several more terms are used in the analysis.

\(^{41}\) Hawes and Foley, 211.
\(^{42}\) Ibid.
1. Probable transition is defined as a transition whose probability is greater than would be expected if all possible transitions were equally probable. (For the matrices used here, transitions greater than .125 are probable transitions.)

2. Divergent configuration is a configuration whose relative entropy (ratio of observed entropy to maximum entropy) is greater than 75%. 43

3. An absorbing configuration leads to no other configuration besides itself.

4. A null configuration, in contrast to absorbing configurations, leads to any other configuration but itself. 44

5. A vacant configuration is not entered during an interaction.

6. A loop sequence shows two configurations having each other as a probable transition.

The earlier research questions proposed now may be stated more precisely.

Question 1: What are the characteristic head direction configurations displayed by group one?

Group one most frequently displays three configurations of head direction. During much of the discussion, the triad maintains a 4(000) configuration as illustrated in table 3. The system exhibits this particular configuration during 146 of the 1400 time samples, suggesting that while discussing the human relations problem, X, Y, and Z spent the major portion of the time avoiding each other's gaze. Ironically, the

43 Terms borrowed from Hawes and Foley.
44 Terms borrowed from Hertel.
### TABLE 3
HEAD DIRECTION DATA
GROUP 1

<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrail proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.5%</td>
<td>21.5%</td>
<td>2.10</td>
<td>70.2%</td>
<td>86</td>
</tr>
<tr>
<td>2</td>
<td>13.3</td>
<td>13.3</td>
<td>2.54</td>
<td>84.8</td>
<td>53</td>
</tr>
<tr>
<td>3</td>
<td>8.5</td>
<td>8.5</td>
<td>1.68</td>
<td>55.9</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>36.6</td>
<td>36.6</td>
<td>1.82</td>
<td>60.7</td>
<td>146</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>2.5</td>
<td>2.45</td>
<td>81.6</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>7.5</td>
<td>7.5</td>
<td>2.33</td>
<td>77.7</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>3.3</td>
<td>3.3</td>
<td>2.32</td>
<td>77.2</td>
<td>13</td>
</tr>
<tr>
<td>8</td>
<td>6.8</td>
<td>6.8</td>
<td>1.93</td>
<td>64.2</td>
<td>27</td>
</tr>
</tbody>
</table>
second post frequent configuration displayed (with a frequency of 86) is 1(111), i.e. each group member is looking at one of the other group members. The third configuration (appearing 53 times) is 2(011) with X looking away from the others in the group.

The entropy values for the head direction configuration range from 1.68 to 2.54 bits. This is relatively high: there is low predictability for the subsequent configuration of head movement. Yet a few configurations do show some predictability.

Question 2: What are the characteristic sequences of head direction configurations in group one?

Figure 2 shows that configurations 2(011) and 3(001) form a loop sequence, suggesting that subject Y sometimes alternates looking toward and away from the other group members. Z continued to establish eye contact throughout the loop sequence.

Configuration 4(000) is absorbing. This configuration succeeds itself 65.7% of the time. Configuration 1(111) also succeeds itself often (52.3%) but it displays a 17.4% chance of transferring to configuration 2(011) as well—with X this time looking away. Configuration 4(000) frequently follows 8(010) suggesting that when Y tries to
fig. 2.—transition probabilities for head direction group 1
establish eye contact, the attempt is generally unsuccess-
fal. A 40% probability of 8(010) being succeeded by 4(000) is indicated.

Question 3: What are the characteristic head direction configurations displayed by group two?

Configurations 4(000) and 1(111) also frequently appear during group two's interaction (see table 4). But the sec-
ond group spends an equal amount of time in each configura-
tion in contrast to the first group. They establish mutual eye contact 113 times and no eye contact 129 times in the frame samples.

Group two also illustrates rather high entropy with a range of 1.73 to 2.79 bits. Two configurations this time, 2(011) and 4(000), are the best predictors of subsequent configurations. But for most configurations, predictability is low.

Question 4: What are the characteristic sequences of head direction configurations in group two?

Even though predictability is relatively low for the head level configurations of group two, a few persistent transitional probabilities are evident. Configuration 5(100) and 6(110) form a loop sequence. Configuration 4(000) absorbs itself 67.2% of the time. Configuration 1(111) follows 2(011) quite often (60%) suggesting that when Y and Z are establishing group eye contact, 6 out of
<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrium proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28.7%</td>
<td>28.3%</td>
<td>2.10</td>
<td>70.1%</td>
<td>113</td>
</tr>
<tr>
<td>2</td>
<td>5.3</td>
<td>5.0</td>
<td>1.73</td>
<td>57.8</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>4.5</td>
<td>4.6</td>
<td>2.30</td>
<td>76.7</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>31.5</td>
<td>32.1</td>
<td>1.82</td>
<td>60.8</td>
<td>128</td>
</tr>
<tr>
<td>5</td>
<td>5.7</td>
<td>5.8</td>
<td>2.79</td>
<td>92.9</td>
<td>23</td>
</tr>
<tr>
<td>6</td>
<td>6.8</td>
<td>6.8</td>
<td>2.51</td>
<td>83.8</td>
<td>27</td>
</tr>
<tr>
<td>7</td>
<td>12.5</td>
<td>12.5</td>
<td>2.11</td>
<td>70.6</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>5.0</td>
<td>5.0</td>
<td>2.30</td>
<td>76.8</td>
<td>20</td>
</tr>
</tbody>
</table>
10 times X will do the same at t+1. Once in configuration 1(111), the system remains there 57.5% of the time. Configuration 7(101) also succeeds itself often (49% of the time) as does 8(010) 4 times out of 10. These indicate the variation of head movements displayed during interaction. Configurations 2(011) and 3(001) are null for this group (see Figure 3).

Question 5: What are the characteristic head direction configurations displayed by group three?

This triad differs from the preceding data trend by forming configuration 3(001) 136 times during the interaction (see table 5). The next most frequent configuration is 4(000). Z, then, is the only group member to steadily attempt to make eye contact. The third group continues the trend of relatively high entropic configurations; the range is from 1.50 to 2.43 bits. Only three states have low entropies—2(011), 5(100), and 6(110).

Question 6: What are the characteristic sequences of head direction configurations in group three?

Figure 4 illustrates a busy and rather low transition probability picture of the interaction process. Several loop sequences are apparent between configurations 1(111) and 2(011), 2(011) and 3(001), 3(110) and 4(000), and 3(110) and 7(101). Z, as was true in group one, probably initiated the establishment of the most consistent eye contact.
fig. 3.—transition probabilities for head direction group 2
### Table 5
Head Direction Data
Group 3

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Equilibrium Proportion</th>
<th>Observed Proportion</th>
<th>Entropy (Bits)</th>
<th>Relative Entropy</th>
<th>Observed Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.4%</td>
<td>10.8%</td>
<td>2.43</td>
<td>81.1%</td>
<td>42</td>
</tr>
<tr>
<td>2</td>
<td>15.0</td>
<td>15.0</td>
<td>1.96</td>
<td>65.5</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>34.1</td>
<td>34.1</td>
<td>2.15</td>
<td>71.7</td>
<td>136</td>
</tr>
<tr>
<td>4</td>
<td>23.1</td>
<td>23.1</td>
<td>2.20</td>
<td>73.4</td>
<td>92</td>
</tr>
<tr>
<td>5</td>
<td>1.5</td>
<td>1.5</td>
<td>1.92</td>
<td>63.9</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>1.0</td>
<td>1.0</td>
<td>1.50</td>
<td>50.0</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>11.0</td>
<td>11.0</td>
<td>2.36</td>
<td>78.7</td>
<td>44</td>
</tr>
<tr>
<td>8</td>
<td>3.5</td>
<td>3.5</td>
<td>2.30</td>
<td>76.6</td>
<td>14</td>
</tr>
</tbody>
</table>
fig. 4.—transition probabilities for head direction group 3
The most stable transitions are to the absorbing configuration of 3(001) and from 4(000) to 6(110). Configuration 6(110) follows 4(000) 50% of the time, with X and Y simultaneously establishing group eye contact. Configuration 3(001) succeeds itself 46.3% of the time. Configuration 4(000) also succeeds itself 45.6% of the time. Configurations 5(100) and 6(110) are null, indicating that they never serve as subsequent steps in a sequence.

Question 7: What are the characteristic head direction configurations displayed by group three? (4*)

The fourth triad spends the most time (110 of the time samples exhibit this configuration) in mutual eye contact; 1(111). The second most frequent configuration is 6(110) which appears 87 times (see table 6). Z, then, often avoids the other's gaze or is interested in the environment and so does not look at the fellow group members.

Group four has the highest configuration entropy values of all, meaning that the head activity is generally sporadic and random. The entropy range is from 2.03 to 2.45.

Question 8: What are the characteristic sequences of head direction configurations in group four?

Figure 5 shows that configurations 6(110) and 1(111) form a loop sequence with Z alternately looking at and away from the other group members, but the probabilities are low.
<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrial proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27.5%</td>
<td>27.6%</td>
<td>2.03</td>
<td>67.7%</td>
<td>110</td>
</tr>
<tr>
<td>2</td>
<td>6.0</td>
<td>6.0</td>
<td>2.24</td>
<td>74.6%</td>
<td>24</td>
</tr>
<tr>
<td>3</td>
<td>3.3</td>
<td>3.0</td>
<td>2.42</td>
<td>80.6%</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>17.9</td>
<td>17.8</td>
<td>2.45</td>
<td>81.6%</td>
<td>71</td>
</tr>
<tr>
<td>5</td>
<td>7.5</td>
<td>7.5</td>
<td>2.38</td>
<td>79.4%</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>24.4</td>
<td>21.8</td>
<td>2.27</td>
<td>74.2%</td>
<td>87</td>
</tr>
<tr>
<td>7</td>
<td>7.8</td>
<td>7.8</td>
<td>2.32</td>
<td>77.3%</td>
<td>31</td>
</tr>
<tr>
<td>8</td>
<td>8.5</td>
<td>8.5</td>
<td>2.38</td>
<td>79.3%</td>
<td>34</td>
</tr>
</tbody>
</table>
fig. 5.—transition probabilities for head direction group 4
Of the transition probabilities found in the fourth group, four are noteworthy. Again, the most probable one-step transition is usually for the system to maintain the same configuration from t to t+1. Configuration 1(lll) succeeds itself 58.2% of the time, 6(l10) follows suit 46% of the time, and 4(000) succeeds itself 43.7% of the time. Also, 41.7% of the time, 1(lll) follows 2(011), suggesting X looks at the other group members at t+1 if Y and Z have already established eye contact at t.

Thus, the predictability is low for all groups on the head configuration level. But this is not unexpected. During an interaction, frequent eye contact and head direction changes are made as nonverbal displays are registered and the environment is examined.

Question 9: What are the characteristic body position configurations displayed by group one?

Group one is most often characterized by the appearance of configuration 5(l1l), indicating X, Y, and Z are all leaning forward. Of the 1400 time samples, 252 display this configuration (see table 7). But a substantial amount of time is also spent in configuration 14(l10). Thus, Z is the only group member to lean back during 144 of the states sampled.
## TABLE 7

**BODY POSITION DATA GROUP 1**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Equilibrium proportion</th>
<th>Observed proportion</th>
<th>Entropy (bits)</th>
<th>Relative entropy</th>
<th>Observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>31.5%</td>
<td>63.2%</td>
<td>0.22</td>
<td>7.3%</td>
<td>252</td>
</tr>
<tr>
<td>10</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0.3</td>
<td>0.5</td>
<td>0.00</td>
<td>0.0</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>0.3</td>
<td>0.3</td>
<td>0.00</td>
<td>0.0</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>18.0</td>
<td>36.1</td>
<td>0.41</td>
<td>13.8</td>
<td>144</td>
</tr>
<tr>
<td>15</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>8</td>
</tr>
</tbody>
</table>
The entropy is extremely low, ranging from 0.00 to 0.41. This striking predictability is due to a general lack in body movement throughout the interaction. Group one maintained a basically forward position during the discussion. Z, however, did light up a cigarette after a time and leaned back while smoking.

Question 10: What are the characteristic sequences of body position configurations in group one?

Figure 6 shows that all configurations are vacant but the previously mentioned 9(111) and 14(110) which are absorbing. Configuration 9(111) succeeds itself 96.8% of the time and 14(110) does the same 93.7% of the time.

Question 11: What are the characteristic body position configurations displayed by group two?

The second group displays a configuration pattern almost directly opposite to the first group's. Group two forms configuration 11(001) as Z leans forward and X and Y lean back 137 times during the 1400 time samples (see table 8). Configuration 12(000) is also often exhibited (121 times) indicating X, Y, and Z are all leaning back.

Again, low entropy is found, ranging from 0.28 to 0.92 bits. This suggests (and figure 7 supports the notion) that there is more body movement in this group than in the preceding group. But there is still a high probability of each configuration succeeding itself.
fig. 6.--transition
probabilities of body position
group 1
<table>
<thead>
<tr>
<th>Configuration</th>
<th>Equilibrium Proportion</th>
<th>Observed Proportion</th>
<th>Entropy (bit)</th>
<th>Relative Entropy</th>
<th>Observed Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>0.0%</td>
<td>3.5%</td>
<td>0.37</td>
<td>12.4%</td>
<td>14</td>
</tr>
<tr>
<td>10</td>
<td>2.6%</td>
<td>5.3%</td>
<td>0.55</td>
<td>18.3%</td>
<td>21</td>
</tr>
<tr>
<td>11</td>
<td>33.9%</td>
<td>34.3%</td>
<td>0.28</td>
<td>9.2%</td>
<td>137</td>
</tr>
<tr>
<td>12</td>
<td>34.2%</td>
<td>30.3%</td>
<td>0.51</td>
<td>16.9%</td>
<td>121</td>
</tr>
<tr>
<td>13</td>
<td>7.4%</td>
<td>6.5%</td>
<td>0.89</td>
<td>28.2%</td>
<td>26</td>
</tr>
<tr>
<td>14</td>
<td>13.0%</td>
<td>12.0%</td>
<td>0.77</td>
<td>25.6%</td>
<td>48</td>
</tr>
<tr>
<td>15</td>
<td>0.8%</td>
<td>0.9%</td>
<td>0.92</td>
<td>30.6%</td>
<td>3</td>
</tr>
<tr>
<td>16</td>
<td>8.0%</td>
<td>7.3%</td>
<td>0.69</td>
<td>23.0%</td>
<td>28</td>
</tr>
</tbody>
</table>
fig. 7.—transition probabilities for body position
group 2
Question 12: What are the characteristic sequences of body position configurations in group two?

The system exhibits several basic body shifts, but they are held for a relatively long time. The percentages of each configuration remaining stationary are:

- 9(111) to 9 -- 92.9%
- 10(011) to 10 -- 90.5%
- 11(001) to 11 -- 96.3%
- 12(000) to 12 -- 92.6%
- 13(100) to 13 -- 89.8%
- 14(110) to 14 -- 87.5%
- 15(101) to 15 -- 66.7%
- 16(010) to 16 -- 86.2%

All configurations, with the exception of 13(100) and 15(101), are absorbing. Configuration 15(101) is followed by 11(001) 33% of the time. This suggests a relatively frequent body shift by 2.

Question 13. What are the characteristic body position configurations displayed by group three?

Table 9 shows that only one configuration in group three is frequently displayed -- 14(110). Again, as is the case in group one, 2 is leaning back during much of the discussion (313 times).

The entropy is still low, ranging from 0.00 to 1.18 bits (see table 9). Thus, the predictability of subsequent configurations is high.

Question 14: What are the characteristic sequences of body position configurations in group three?
<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrial proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>7.9%</td>
<td>11.5%</td>
<td>0.71</td>
<td>23.8%</td>
<td>46</td>
</tr>
<tr>
<td>10</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0.3</td>
<td>0.5</td>
<td>0.08</td>
<td>0.0</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>5.0</td>
<td>8.0</td>
<td>1.18</td>
<td>39.5</td>
<td>32</td>
</tr>
<tr>
<td>14</td>
<td>48.4</td>
<td>78.5</td>
<td>0.52</td>
<td>17.3</td>
<td>313</td>
</tr>
<tr>
<td>15</td>
<td>0.0</td>
<td>0.0</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>0.9</td>
<td>1.5</td>
<td>0.92</td>
<td>30.6</td>
<td>6</td>
</tr>
</tbody>
</table>
There is more movement from one configuration to another in this group than in the other groups (see figure 8). Configuration 14(110) is absorbing. It succeeds itself 92.3% of the time. It follows 13(100) 92.3% of the time, 16(010) 66.7% of the time, and 9(111) 19.6% of the time. Configuration 9(111) succeeds itself 8 out of 10 times, as does 13(100) 7 out of 10 times. Thus, if X is leaning forward, Y will often do the same in the next frame. Similarly, if Y is leaning forward, X will also lean forward in the next time sample. If X, Y, and Z all are leaning forward, sometimes Z will lean back at t+1. As indicated above, Z generally maintains a backward leaning position.

Question 15: What are the characteristic body position configurations displayed by group four?

The fourth group indicates a more even dispersion of activity. The most characteristic configuration here is 9(111), i.e. X, Y, and Z lean forward simultaneously. This occurs 164 times (see table 10). The next most frequently appearing configuration is 13(100). X is leaning forward and Y and Z are leaning back during 84 of the time samples.

The entropy values are low for the fourth group, too. The range is from 0.71 to 1.68, signifying high predictability of subsequent configurations.

Question 16: What are the characteristic sequences of body position configurations in group four?
fig. 8. — transition probabilities for body position group 3
<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrium proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>39.7%</td>
<td>41.1%</td>
<td>0.72</td>
<td>24.1%</td>
<td>164</td>
</tr>
<tr>
<td>10</td>
<td>4.5</td>
<td>5.3</td>
<td>1.88</td>
<td>62.6</td>
<td>21</td>
</tr>
<tr>
<td>11</td>
<td>5.7</td>
<td>7.8</td>
<td>0.71</td>
<td>23.6</td>
<td>31</td>
</tr>
<tr>
<td>12</td>
<td>2.0</td>
<td>1.8</td>
<td>1.38</td>
<td>46.0</td>
<td>7</td>
</tr>
<tr>
<td>13</td>
<td>25.0</td>
<td>21.8</td>
<td>0.80</td>
<td>26.7</td>
<td>87</td>
</tr>
<tr>
<td>14</td>
<td>6.2</td>
<td>5.8</td>
<td>1.77</td>
<td>59.0</td>
<td>21</td>
</tr>
<tr>
<td>15</td>
<td>15.7</td>
<td>16.0</td>
<td>1.01</td>
<td>34.3</td>
<td>64</td>
</tr>
<tr>
<td>16</td>
<td>1.1</td>
<td>0.5</td>
<td>1.00</td>
<td>33.3</td>
<td>2</td>
</tr>
</tbody>
</table>
Figure 9 shows a loop sequence between $11(001)$ and $10(011)$. But, as found in the other groups, it is most probable that each configuration will remain constant in $t+1$. This is illustrated by the probability that $9(111)$ will succeed itself 87.2% of the time, $13(100)$ will follow itself 86.2% of the time, $11(001)$ will succeed itself 80.6% of the time, $15(101)$ succeeds itself 75% of the time, $12(000)$ follows itself 57.1% of the time, and $16(010)$ follows itself 50% of the time, which all suggests much movement by the group members. Yet, of these, only configuration $13(100)$ is absorbing. A shift in behavior displays is found as $13(100)$ succeeds $16(010)$ 50% of the time. This indicates a frequent complementary movement of Y leaning back as X leans forward.

Unlike the head direction level, the body position configurations are marked by high predictability, and most often the configuration remains stationary from $t$ to $t+1$.

Question 17: What are the characteristic arm extension configurations displayed by group one?

Group one most often exhibits two arm extension configurations—$20(000)$ and $19(001)$. During 147 of the time samples, $X$, $Y$, and $Z$ are sitting with their hands clasped or their arms crossed. But in 228 of the time frames, $Z$ has an arm or both arms extended (see table 11). This is not unusual since the subject is holding a cigarette.
fig. 9.--transition probabilities for body position
group 4
<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrium proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.00</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>18</td>
<td>1.1</td>
<td>1.5</td>
<td>0.65</td>
<td>21.7</td>
<td>6</td>
</tr>
<tr>
<td>19</td>
<td>42.8</td>
<td>57.1</td>
<td>0.40</td>
<td>13.4</td>
<td>228</td>
</tr>
<tr>
<td>20</td>
<td>27.7</td>
<td>36.8</td>
<td>0.55</td>
<td>18.5</td>
<td>147</td>
</tr>
<tr>
<td>21</td>
<td>1.9</td>
<td>2.5</td>
<td>0.97</td>
<td>32.4</td>
<td>10</td>
</tr>
<tr>
<td>22</td>
<td>0.0</td>
<td>0.6</td>
<td>0.00</td>
<td>0.0</td>
<td>0</td>
</tr>
<tr>
<td>23</td>
<td>0.8</td>
<td>1.0</td>
<td>0.81</td>
<td>27.0</td>
<td>4</td>
</tr>
<tr>
<td>24</td>
<td>0.8</td>
<td>1.0</td>
<td>1.00</td>
<td>33.3</td>
<td>4</td>
</tr>
</tbody>
</table>
The entropy values range from 0.00 to 0.97, indicating very high predictability of subsequent configurations. And, of the eight potential configurations, two—17(111) and 22(110)—are vacant, meaning that all three group members never gesture or move their arms simultaneously, nor do X and Y move their arms simultaneously. The configurations are established so that either X and Z or Y and Z are the only two possible combinations for simultaneous movement.

**Question 16:** What are the characteristic sequences of arm-extension configurations in group one?

Figure 10 illustrates that the most common one-step transition is for each configuration to remain stationary. Both highly frequented configurations—19(001) and 20(000)—are absorbing. Configuration 20(000), indicating all subjects have their arms together, repeats itself more often than nine times out of ten. Configuration 19(001) follows itself 94.3% of the time. It also is a highly probable subsequent configuration for both 14(011), occurring 83.3% of the time, and 23(101), occurring 73% of the time. This suggests a continuous arm extension by Z while X extends and then retracts an arm or arms or Y extends and then retracts an arm or arms. Configuration 20(000) also probably follows two configurations besides itself—24(010) 50% of the time, and 21(100) 40% of the time. The interpretation is similar to the previous transition patterns,
fig. 10.--transition probabilities for arm extension group 1
only this time Z is not displaying any arm movement. Those two configurations are also likely to follow themselves. Configuration 21(100) follows itself 60% of the time, and 24(010) succeeds itself 40% of the time.

Question 19: What are the characteristic arm extension configurations displayed by group two?

Members of group two generally keep their hands together (see table 12). Configuration 20(000) is displayed in 197 of the 1400 time samples. The other time samples show a more even dispersion of behavior among the potential configurations than is the case in the first group, although one configuration is vacant—22(110). As with group one, X and Y never display simultaneous arm movements. Only X and Z, and Y and Z may do so.

The entropy values are again low, ranging from 0.00 to 1.38 bits. Thus, there is high predictability of subsequent configurations.

Question 20: What are the characteristic sequences of arm extension configurations in group two?

A loop sequence appears between 8(011) and 13(001) with Z extending an arm or arms and Z alternately extending or retracting an arm (see figure 11). But as generally been the case throughout this analysis, the most frequent transition is for the configurations to succeed themselves.
<table>
<thead>
<tr>
<th>Configuration</th>
<th>Equilibrial Proportion (%)</th>
<th>Observed Proportion (%)</th>
<th>Entropy (bits)</th>
<th>Relative Entropy (%)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>0.5%</td>
<td>0.5%</td>
<td>1.00</td>
<td>31.3%</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>10.5</td>
<td>10.5</td>
<td>1.38</td>
<td>46.1</td>
<td>42</td>
</tr>
<tr>
<td>19</td>
<td>15.3</td>
<td>15.3</td>
<td>1.30</td>
<td>43.5</td>
<td>61</td>
</tr>
<tr>
<td>20</td>
<td>49.4</td>
<td>49.4</td>
<td>0.81</td>
<td>27.0</td>
<td>197</td>
</tr>
<tr>
<td>21</td>
<td>6.3</td>
<td>6.3</td>
<td>1.25</td>
<td>42.4</td>
<td>25</td>
</tr>
<tr>
<td>22</td>
<td>0.5</td>
<td>0.5</td>
<td>0.00</td>
<td>0.0</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>0.8</td>
<td>0.8</td>
<td>0.92</td>
<td>30.6</td>
<td>3</td>
</tr>
<tr>
<td>24</td>
<td>16.8</td>
<td>16.8</td>
<td>1.14</td>
<td>38.1</td>
<td>65</td>
</tr>
</tbody>
</table>
Fig. 11.-Transition probabilities for arm extension group 2
Two configurations are absorbing, 20(000) and 21(100). Configuration 20(000) succeeds itself 96.3% of the time and it succeeds 24(010) 28.4% of the time. Configuration 21(100) succeeds itself 72% of the time. Furthermore, 18(011) repeats itself 64.3% of the time, 19(001) succeeds itself 72.1% of the time, 23(101) succeeds itself 33% of the time, and 24(010) succeeds itself 67.2% of the time. Configuration 19(001) also follows 23(101) more than six times out of ten, indicating that simultaneous arm movement by X and Z is likely to be succeeded by X's discontinuance of the act.

Configuration 17(111) is null. From 17(111) there is a 50/50 chance that the system will either enter configuration 18(011) or 19(001) with X discontinuing arm movement or X and Y both discontinuing arm movement at t+1.

Question 21: What are the characteristic arm direction configurations in group three?

Group three displays configuration 21(100) 105 times during the interaction (see table 13). Thus, X is extending an arm or arms relatively consistently throughout the interaction. The other seven configurations are entered at a frequency range of 31-66 times.

The entropy values also range from 1.32 to 1.99 bits; predictability of subsequent configurations is high.
<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrium proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>9.5%</td>
<td>9.5%</td>
<td>1.32</td>
<td>43.9%</td>
<td>33</td>
</tr>
<tr>
<td>18</td>
<td>5.8</td>
<td>5.8</td>
<td>1.56</td>
<td>52.2</td>
<td>23</td>
</tr>
<tr>
<td>19</td>
<td>13.0</td>
<td>13.0</td>
<td>1.36</td>
<td>45.4</td>
<td>52</td>
</tr>
<tr>
<td>20</td>
<td>10.5</td>
<td>10.5</td>
<td>1.69</td>
<td>56.3</td>
<td>42</td>
</tr>
<tr>
<td>21</td>
<td>26.3</td>
<td>26.3</td>
<td>1.35</td>
<td>45.0</td>
<td>105</td>
</tr>
<tr>
<td>22</td>
<td>10.5</td>
<td>10.5</td>
<td>1.92</td>
<td>66.4</td>
<td>42</td>
</tr>
<tr>
<td>23</td>
<td>16.5</td>
<td>16.5</td>
<td>1.51</td>
<td>50.2</td>
<td>66</td>
</tr>
<tr>
<td>24</td>
<td>7.8</td>
<td>7.8</td>
<td>1.67</td>
<td>55.6</td>
<td>31</td>
</tr>
</tbody>
</table>
Question 22: What are the characteristic sequences of arm extension configurations in group three?

Loop sequences are exhibited between 19(001) and 23(101) and between 20(000) and 24(010). Configuration 21(100) is absorbing (see figure 12). As in the past groups, the highest probable transitions are for a configuration to remain constant, suggesting that arm movements are continued over relatively long periods of time rather than at random time intervals. Probabilities of the system remaining in a current configuration are:

17(111) to 17=73.7%
18(011) to 18=60.4%
19(001) to 19=67.3%
20(000) to 20=59.5%
21(100) to 21=73.3%
22(110) to 22=54.8%
23(101) to 23=66.7%
24(010) to 24=54.8%

Question 23: What are the characteristic arm extension configurations displayed by group four?

Configuration 20(000) is very characteristic of group four. Occurring 225 times out of 1400, it suggests that the group displays very little arm movement during the interaction (see table 14).

Thus, predictability of subsequent configurations is high as shown by the entropy value range of 0.00 to 1.43.

Question 24: What are the characteristic sequences of arm extension configurations in group four?
fig. 12. -- transition probabilities for arm extension group 3
<table>
<thead>
<tr>
<th>configuration</th>
<th>equilibrium proportion</th>
<th>observed proportion</th>
<th>entropy (bits)</th>
<th>relative entropy</th>
<th>observed frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>0.4%</td>
<td>0.5%</td>
<td>1.00</td>
<td>33.3%</td>
<td>2</td>
</tr>
<tr>
<td>18</td>
<td>7.2%</td>
<td>8.3%</td>
<td>1.18</td>
<td>39.3%</td>
<td>33</td>
</tr>
<tr>
<td>19</td>
<td>13.4%</td>
<td>15.3%</td>
<td>1.43</td>
<td>47.6%</td>
<td>61</td>
</tr>
<tr>
<td>20</td>
<td>51.2%</td>
<td>58.9%</td>
<td>1.09</td>
<td>36.5%</td>
<td>225</td>
</tr>
<tr>
<td>21</td>
<td>2.0%</td>
<td>2.3%</td>
<td>0.76</td>
<td>25.5%</td>
<td>9</td>
</tr>
<tr>
<td>22</td>
<td>0.4%</td>
<td>0.5%</td>
<td>1.00</td>
<td>33.3%</td>
<td>2</td>
</tr>
<tr>
<td>23</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.00</td>
<td>00.0%</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>12.9%</td>
<td>14.3%</td>
<td>1.32</td>
<td>44.1%</td>
<td>57</td>
</tr>
</tbody>
</table>
Figure 13 indicates that 20(000) is absorbing and is the most likely subsequent configuration for 19(001) 63.9% of the time, 21(100) 77.8% of the time, 22(110) 50% of the time, and itself 80.4% of the time. Two configurations are null—17(111) and 22(110). Thus, X, Y, and Z or X and Y only establish simultaneous arm movement as an antecedent step. As with group two, 17(111) is followed 50% of the time by 18(011) and 50% of the time by 19(001). Configuration 22(110) also displays a 50% probability of forming 20(000) and 21(100).

Configuration 23(101) is vacant, meaning X and Z never display simultaneous arm movement. If any movement occurs, any combination of X, X and Y, Y, or Y and Z making some sort of arm extension is possible, but infrequent.

There is a noteworthy relationship between 17(111), 18(011), and 19(001) which is nearly identical to one found in group two (see figure 11).

High predictability for subsequent configurations is exhibited by all four groups. The most frequent configuration displayed in each system is 20(000), meaning no arm extension is made by any group member. When movement is present, Z is frequently the most active in each group.

question 25: To what extent are sequences of head direction configurations stable across similarly structured groups?
fig. 13. --transition probabilities for arm extension group 4
A null hypothesis is framed to assess this question.

Hypothesis 1: Transition probabilities from all head level configurations are the same in the individual group matrices as in the composite matrix.

As discussed earlier in this paper, the Anderson and Goodman likelihood statistic is employed to test the configuration transition probability for stability. In oversimplified terms, the likelihood statistic compares the transition probability of a composite matrix to that of an individual matrix transition frequency, yielding a chi square distribution. For this analysis, a chi square of 106.1106 with 168 df is needed for rejection at the .01 alpha level.45

Since the derived chi square for the head direction level is 396.3489, the null hypothesis is not accepted. A discrepancy of that size is not unusual, however, since a large df forces statistical significance from very small differences among the matrices.

In order to seek the specific configurations which are unstable and thereby causing significance, several null sub-hypothoses are examined.

---

45 Degrees of freedom (df) is N(N-1) when N is the number of rows or columns of the matrices.
Hypothesis 1a: Transition probabilities from each
1(111) configuration are the same for each of the
four matrices as in the composite matrix.

For each subhypothesis, 38.9321 with 21 df is needed
to reject the null hypothesis. H\textsubscript{1a} is not accepted since
the chi square value (52.4450) is greater than the level of
significance (see table 15).

Hypothesis 1b: Transition probability from each
2(011) configuration are the same for each of the
four matrices as in the composite matrix.

The derived chi square value (69.0259) is greater than
the level of significance. H\textsubscript{1b} is not accepted.

Hypothesis 1c: Transition probabilities from each
1(001) configuration are the same for each of the
four matrices as in the composite matrix.

The derived chi square value (51.0138) is greater than
the level of significance. H\textsubscript{1c} is not accepted.

Hypothesis 1d: Transition probabilities from each
4(000) configuration are the same for each of the
four matrices as in the composite matrix.

Again, the chi square value (74.3829) is greater than
the level of significance. H\textsubscript{1d} is not accepted.

Hypothesis 1e: Transition probabilities from each
5(100) configuration are the same for each of the
four matrices as in the composite matrix.

The chi square value (19.9500) is less than 38.9321
which is needed for rejection; H\textsubscript{1e} is not rejected. Figure
14 shows that this configuration is absorbing, which indi-
cates that X leaning forward and Y and Z leaning back forms
a consistent subsequent configuration across groups.
<table>
<thead>
<tr>
<th>Group to Composite</th>
<th>Chi Square Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 1</td>
<td>52.4450</td>
</tr>
<tr>
<td>* 2</td>
<td>69.0259</td>
</tr>
<tr>
<td>* 3</td>
<td>51.0138</td>
</tr>
<tr>
<td>* 4</td>
<td>74.3829</td>
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<tr>
<td>5</td>
<td>19.9500</td>
</tr>
<tr>
<td>* 6</td>
<td>44.5670</td>
</tr>
<tr>
<td>* 7</td>
<td>55.4446</td>
</tr>
<tr>
<td>8</td>
<td>29.5200</td>
</tr>
</tbody>
</table>

* Chi square values above .01 significance
fig. 14.--transition probabilities for head direction composite
Hypothesis $H_1$: Transition probabilities from each 6(120) configuration are the same for each of the four matrices as in the composite matrix.

$H_{1g}$ is not accepted since a chi square value of 44.5670 is generated—greater than the rejection level for .01.

Hypothesis $H_2$: Transition probabilities from each 7(101) configuration are the same for each of the four matrices as in the composite matrix.

$H_{2g}$ is not accepted; the chi square value is 55.4446. A value no higher than 38.9321 should have been obtained.

Hypothesis $H_3$: Transition probabilities from each 8(010) configuration are the same for each of the four matrices as in the composite matrix.

With a chi square of 29.5200, the level of rejection at .01 is not reached. Thus, $H_{3g}$ is not rejected. Similarly to 5(100), this configuration is absorbing in the composite. Here, Y leaning forward is a frequent subsequent configuration across groups.

The stability of 5(100) and 8(010) are not unexpected given the discussion of head direction configurations presented earlier in the paper.

Question 26: To what extent are sequences of body position configurations stable across similarly structured groups?

Again, a null hypothesis is framed for testing this question.

Hypothesis 2: Transition probabilities from all body level configurations are the same in the individual group matrices as in the composite matrix.
The likelihood statistic yields a chi square of 248.7958—again higher than the chi square value (106.1106) needed for rejection at the .01 level. In order to isolate specific unstable configurations which might be causing the level instability, several hypotheses were examined.

Hypothesis 2a: Transition probabilities from each 9(111) configuration are the same for each of the four matrices as in the composite matrix.

Table 16 shows that 9(111) has a chi square value of 58.8372, which is greater than the value for rejection—38.9321 at the .01 alpha level. H2a is not accepted.

During the discussion earlier it was noted that 9(111) is rarely a subsequent configuration. X, Y, and Z leaning forward simultaneously is a rare occurrence except in group four.

Hypothesis 2b: Transition probabilities from each 10(011) configuration are the same for each of the four matrices as in the composite matrix.

With 15.8576, this configuration does not reach significance; H2b is not rejected. Figure 15 illustrates why this and six other configurations accept the null hypothesis. They are all absorbing. The two configurations which are not absorbing are the ones which show significance.

Hypothesis 2c: Transition probabilities from each 11(001) configuration are the same for each of the four matrices as in the composite matrix.
<table>
<thead>
<tr>
<th>group to composite</th>
<th>chi square value</th>
</tr>
</thead>
<tbody>
<tr>
<td>* 9</td>
<td>58.8372</td>
</tr>
<tr>
<td>10</td>
<td>15.8576</td>
</tr>
<tr>
<td>11</td>
<td>35.1985</td>
</tr>
<tr>
<td>12</td>
<td>36.9388</td>
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<tr>
<td>13</td>
<td>18.9853</td>
</tr>
<tr>
<td>* 14</td>
<td>62.8621</td>
</tr>
<tr>
<td>15</td>
<td>4.9331</td>
</tr>
<tr>
<td>16</td>
<td>15.1833</td>
</tr>
</tbody>
</table>

* chi square values above .01 significance
fig. 15.--Transition probabilities for body position composite
The chi square value is 35.1985; $H_2_c$ is not rejected.

Hypothesis $2_d$: Transition probabilities from each 12(000) configuration are the same for each of the four matrices as in the composite matrix.

The chi square value is 36.9388; $H_2_d$ is not rejected.

Hypothesis $2_e$: Transition probabilities from each 13(100) configuration are the same for each of the four matrices as in the composite matrix.

The chi square value is 18.9853; $H_2_e$ is not rejected.

Hypothesis $2_f$: Transition probabilities from each 14(110) configuration are the same for each of the four matrices as in the composite matrix.

The chi square value is 62.8621; $H_2_f$ is not accepted.

This is the other non-absorbing configuration.

Hypothesis $2_g$: Transition probabilities from each 15(101) configuration are the same for each of the four matrices as in the composite matrix.

The chi square value is 4.9331; $H_2_g$ is not rejected.

Hypothesis $2_h$: Transition probabilities from each 16(010) configuration are the same for each of the four matrices as in the composite matrix.

The chi square value is 15.1833; $H_2_h$ is not rejected.

A reason for this display of stability was suggested previously in the paper: there is very little body shifting during the short discussions. Thus, the composite map illustrates that each configuration is likely to maintain its form at 5+1 7 to 9 times out of 10.

The final nonverbal level examined in this analysis is arm extension.
Question 27: To what extent are sequences of body position configurations stable across similarly structured groups?

The null hypothesis for testing this question is:

Hypothesis 3: Transition probabilities from all arm level configurations are the same in the individual group matrices as in the composite matrix.

The chi square produced is 278.7551—greater than the 106.1166 significance level. Thus, the null hypothesis is not accepted for the third time.

Application of the subhypotheses show that there are specific areas of stability, however.

Hypothesis 3a: Transition probabilities from each 17(111) configuration are the same for each of the four matrices as in the composite matrix.

As with the body position configurations, there are only two configurations on the arm level which do not display stability during this type of examination. The 13.2340 chi square value is less than the significance level of 38.932 with 21 df. Configuration 17(111) is absorbing in the composite. Thus, $H_{3a}$ is not rejected.

Hypothesis 3b: Transition probabilities from each 18(011) configuration are the same for each of the four matrices as in the composite matrix.

Table 17 indicates that 18(011) has a chi square value of 21.8154. This being lower than significance, $H_{3b}$ is not rejected. Unlike 17(111), 18(011) is not absorbing, but the transition probability out of 18(011) is small (see figure 16).
<table>
<thead>
<tr>
<th>group to composite</th>
<th>chi square value</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>13.2340</td>
</tr>
<tr>
<td>18</td>
<td>21.8154</td>
</tr>
<tr>
<td>* 19</td>
<td>101.4590</td>
</tr>
<tr>
<td>* 20</td>
<td>49.1828</td>
</tr>
<tr>
<td>21</td>
<td>38.2267</td>
</tr>
<tr>
<td>22</td>
<td>13.2430</td>
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<tr>
<td>23</td>
<td>11.4850</td>
</tr>
<tr>
<td>24</td>
<td>30.1093</td>
</tr>
</tbody>
</table>

* chi square values above .01 significance
fig. 16.—transition probabilities for arm extension composite
Hypothesis $3_2$: Transition probabilities from each 19(001) configuration are the same for each of the four matrices as in the composite matrix.

Configuration 19(001) has a chi square value of 101.4590; $H_{3_2}$ is not accepted. Even though much time is spent in this configuration by all four groups, 9(001) weakens its consistency by also occasionally preceding other configurations.

Hypothesis $3_3$: Transition probabilities from each 20(000) configuration are the same for each of the four matrices as in the composite matrix.

With a chi square value of 49.1828, this configuration closely resembles the previous one. $H_{3_3}$ is not accepted. Like 19(001), 20(000) is frequently displayed by all groups. The difference between 19(001) and 20(000) is only an arm extension by $z$, and, as is the case with 19(001), 20(000) weakens its stability by occasionally preceding other configurations.

Hypothesis $3_4$: Transition probabilities from each 21(100) configuration are the same for each of the four matrices as in the composite matrix.

The chi square is 38.2267; $H_{3_4}$ is not rejected. As is the case with 18(011), there is a possibility of 21(100) forming another configuration at t+1, but the probability is so small—the configuration is considered stable.

Hypothesis $3_5$: Transition probabilities from each 22(110) configuration are the same for each of the four matrices as in the composite matrix.
The remaining three configurations are stable because they are absorbing in the composite map. Configuration 99(110) has a chi square value of 13.2430; H3g is not rejected.

Hypothesis 3h: Transition probabilities from each 23(101) configuration are the same for each of the four matrices as in the composite matrix.

The chi square is 11.4850; H3g is not rejected.

Hypothesis 3i: Transition probabilities from each 24(010) configuration are the same for each of the four matrices as in the composite matrix.

The chi square is 30.1093; H3i is not rejected at the .01 alpha level.

As the hypotheses indicate, stability for each level of the nonverbal subsystem is not found when comparing each system's matrix to the composite matrix. This conclusion is similar to other findings by Lewis and Hawes and Foley, i.e. stability is not present across groups.

The subhypotheses acknowledge some configuration transition stability when comparing all configurations of all four matrices to all configurations of the composite matrix. The individual stable configurations occur in either the body position or the arm extension level of the nonverbal subsystem.
These analyses suggest that often a group member moves very little during interaction and, if he/she does change positions, the new position will then be held for an indefinite period.

The next section contains a discussion on the methods employed for collection and analysis of data, the findings of this study, and a projection for future studies.
DISCUSSION

Through the use of the Markov model, it is possible to sample behaviors over time. A simple Markov chain focuses attention on sequences of one-step transitions during the interaction process.

In representing a sequence by a matrix, one ignores all the properties of the sequence except relative contingency (transitions) frequencies. If a sequence can be described completely by such a matrix, the sequence may be called Markovian.46

By plotting sequential configurations on a graph, a circular, tree-branching, or some other patterning may result—which characterizes process. Many such graphs, focusing on various types of communication systems and environments, could yield heuristic information on the nature of process. This emphasis on transitions between behaviors over time is relatively new in the social and behavioral sciences. Thus far, studies in this vein often have been conceived in the fields of psychiatry and psychology. Therefore, the non-therapeutic discussion group has largely been ignored.

46Hertel, 425.

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Nonverbal behavior is included in some coding strategies for interaction research, but often it is used as an inferential aid in assessing an affective state of an individual. A straightforward description of behaviors, without inferring either semantics or intent, is now occasionally attempted.

But the emphasis on nonverbal behaviors as an indicator of interaction (i.e. defining the nature of an interaction process) seldom is presented. Traditionally, the nonverbal behaviors are described as manifested by an individual or individuals. With the assumed influence of the group as an entity in itself, though, it is apparent that the combined configuration of nonverbal behaviors should be examined as a manifestation of the group system.

To concentrate on this perspective, the group is considered one organism, rather than a cluster consisting of members X, Y, and Z—although for description's sake in this study, the results were explicated by detailing X, Y, or Z's manifested nonverbal behaviors. X, Y, and Z were considered components of the system, however.

In sum, the figures and tables used here are graphic representations of process. The communication level examined

47 Sales, "A Set of Categories for the Analysis of Small Group Interaction."
is the nonverbal subsystem. The system is a nontherapeutic discussion group. And four of these systems are compared for similar characteristics in process.

When all graphs for one nonverbal level are placed together and held up to a light, a remarkable similarity is evident, especially for the body position level. Although the Anderson and Goodman likelihood statistic produced chi square values great enough to reject the null hypothesis of stability across groups for each of the nonverbal levels, some transitions from a configuration to one other than itself, e.g. from 1(111) to 3(011) appear similar across groups. Each group establishes its own character or pattern early in the interaction process, but there is still some similarity between the four groups. Thus, groups of similar size, group history, and task orientation may indicate a generalizable characteristic graph formation for that type of interaction. And, as more refined categories are developed, a very detailed and complex picture of process is a hopeful outcome.

But, to sample process, it is necessary to have a sampling device. As previously discussed in this paper, there are many advantages for the filmic methods of recording data. Films can capture very complex events. No observers need be present during the original interaction.
The camera can be set to shoot at specific times in case it is difficult or unadvisable for an observer to be present during the interaction. If a complex system of coding is needed for a study, the visual record is very helpful since it may be reviewed again and again. The films also serve as a data library for any potential borrowers. If special effects are needed to aid the analysis, such items as superimposed grids, split frame effects, and masked frame effects are possible.

Videotaping has several advantages over film. The tape can be replayed immediately after recording. It also may be erased and rerecorded. There is little expense involved since there are no processing costs to contend with. Finally, the videotape recorder is lighter than a comparable motion picture camera. The film medium has some other disadvantages in the brightness of the lights necessary for filming, and the noise of the cameras.

Despite all this, motion picture film has a few very important advantages for studying the nonverbal subsystem. First, resolution of the image is superior to the videotape; the smallest facial movement may be examined easily since the image can be greatly enlarged for better viewing. If, during analysis or data collection, either a slower or
faster film speed than 24 fps is needed, the motion picture camera or projector can be set accordingly. Furthermore, one frame may be held on a screen indefinitely for careful inspection. Attempting to hold a videotaped image still results in a distorted and vibrating picture.

But the deciding factor is that the time lapse device has no corresponding technique in videotape. As was discussed earlier, the time lapse camera samples sequential time in measured intervals. Thus, unlike the "direct observation every 5 seconds for 5 seconds" technique, the information is contained in one discrete time frame. The intervals between samples may be made quite large or small. The 1-frame-every-2-seconds timing used for this study was an arbitrary decision. Other time intervals for sampling interaction process can and should be made to establish a range of adequate but not overabundant frequencies for a study.

One problem now with the technical side of the data collection method is the noise of the cameras and the necessary presence of spotlights. A few Ss mentioned discomfort—not with the cameras' presence—but because of the constant clicking sound of the time lapse motor and the brightness of the lights. For future studies using time
lapse photography for sampling process, care must be taken to eliminate, as much as possible, these distractions. A laboratory room might be structured to conceal the cameras in tables or behind one-way mirrors. Unfortunately, this seriously limits the use of the method to the laboratory setting, although the system could be permanently set up in an office of some kind. With a bit of trouble and much visible equipment, the system could be moved outside, but this appears impractical at present.

Some innovations in the camera or the setup of the experiment room may provide new insights for handling both time and space simultaneously. Perhaps a system of cameras or a combination of mirrors and cameras may be developed, capable of collapsing the three-dimensional subject field onto the two-dimensional film surface (e.g. a front, back and side view of the subject might all go on the same piece of celluloid).

There is a distinct need for sophisticated methodological strategies to test new theories in communication. It is hoped this paper will serve to tempt others into trying this particular collection and analysis method. And it is hoped that the methods will be flexible enough to suggest new directions of enquiry.
To sum, then, the time sampling device of the time lapse camera combined with the transition probability model for analysis could well be a key toward examining the ways a communication system behaves over time, and measuring that process of change. It is acknowledged that from the current study, the researcher can generalize about nonverbal process only for the four specific triads examined. Yet, if more studies such as this are done, the heuristic and holistic emphasis of the systems approach may lead to some clues as to how a group displays its groupness and what parts nonverbal behaviors play in group structure and process.
INTERACTION


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**OTHER**


